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ORGANIC VARIATION.

BY CHAS. MORRIS.

The recent paper in THE NATURALIST, by Prof. Osborn,[1] on variation in organisms, and the seeming presence of certain unknown factors in development which give rise to phenomena not included in the accepted theories, suggests the desirability of further consideration of this topic. The problem is a most intricate one, the final result being affected by every external condition to which the organism is exposed throughout its whole career, and by various internal influences which are far more difficult to trace, yet are, perhaps, the leading forces at work.

The effects of environment have been abundantly dealt with and are somewhat fully understood. It is not necessary here to state the principles of Lamarckism and Darwinism. It will suffice to say that they do not embrace the whole problem. Darwinism does not attempt to do so, since it takes the great fact of variation for granted and works from that as a basis. Lamarckism attempts to explain variation, as due to use and to the resulting strain upon the organism. But it evidently does not reach the great class of individual variations which are opposed to heredity, and whose cause lies deep in the organism and must be sought in the conditions of the germinal cell itself.

Of the two great underlying principles involved in organic evolution, heredity and variation, the former seems much the most comprehensible. It is but natural to expect that the germ should unfold in the manner of that from which it was derived. Such native tendencies as exist in it must be derived from the parents, and bear a resemblance to those that have been active in the parental organisms. As a result, if parthenogenesis prevailed, we should naturally expect every offspring to repeat all the peculiarities of its parent—all variation being due to subsequent influences of the environment. In the case of two parents, the offspring might be expected to possess characteristics of each, now being strictly intermediate, now approaching one parent more nearly than the other. In this method of variation, which is nearly all that Weissmann admits, the steady tendency must be to swamp all distinctions, the differences between parents continually diminishing. In short, these differences could never have arisen were heredity the only force at work. Darwinism has a similar tendency, since varying and ill-adapted organisms tend to disappear, and only those with close similarities of adaptation to be preserved. The changes due to Lamarckian influences must tend also in the direction of uniformity, through a general movement of adaptation to fixed conditions.

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[1] May, 1895.

Yet this fixed tendency towards uniformitarianism is not what nature displays. Marked individual variations constantly appear, the seeming efforts of nature to produce similar forms being checked at every point by individual peculiarities of constitution. These variations are in opposition to the influences of heredity, natural and sexual selection, use and effort, all of which tend to uniformity. To what are they due? Can a parent transmit to its offspring characteristics which it does not possess itself? This does not seem possible; the natural conclusion being that the offspring should repeat the peculiarities of the parent or parents existing at the period of its birth.

Yet has heredity as overmastering an influence as many ascribe to it? Even if we decline to accept the Weissmann hypothesis, and hold that every portion of the organism, in some way, exerts a direct influence upon the developing germ, it is not impossible that this influence may differ in energy in different organisms, in some cases controlling almost absolutely the constitution of the germ, in others permitting foreign influences, external or internal, to operate to some extent, with consequent variations in germinal constitution.

Several hypotheses have been advanced in explanation of heredity, none of them based sufficiently on discovered facts to be quite satisfactory, and all of them leaving it possible that the germinal cell may not be rigidly controlled in its development by hereditary influences, but may have a degree of independence and susceptibility to the action of minor and local influences. As variation cannot well be due to influences proceeding from the parental organisms, it certainly seems as if it must arise from conditions existing in the environment of the developing germ and embryo, or to internal molecular forces, left free to produce variations by a degree of weakness in the hereditary influences.

Much certainly depends on the inherent conditions of the reproductive cells. These may vary in developmental energy, through excess or deficiency of nutrition. They may also vary, through position or otherwise, in the quantity of nutriment obtained during development. In consequence, there is probably an active struggle for existence at this low level of life, the numbers involved being considerable, while—in the case of the higher animals—only one or a few can survive. This early competition would seem simply to be one of comparative cell vigor, or of advantage in propinquity to the store of nutriment; but it is, perhaps, not quite so simple. The germinal cell is, to outward appearances, a largely homogeneous organism, but the facts of development prove that it is heterogeneous in constitution, its tendencies and powers being not single but multiple. It probably is made up of various groups of molecules differently arranged or organized, each of which is destined, in its development, to produce a special organ or variety of tissue in the mature form. What we can see very poorly indicates what exists. The compound of organs into which the cell unfolds indicates that conditions preliminary to those organs existed in it, each perhaps located in some definite region of the cell, which may thus be made up of distinct groups of differently organized molecules.

If this, as we have much reason to believe, is the case, the field of competition may be a much more extended one than has been supposed. In addition to competition for nutriment between cells as wholes, there may be an internal competition in each, between its different molecular groups, while differences in original strength may give some of these an advantage over others. Such a difference in original power of absorbing nutriment would, perhaps, grow more declared as development proceeded, and the several molecular groups differentiated into embryo organs.

If such a competition existed, what would be its natural result? Here we have the principle of survival—or, at least, of precedence—of the fittest active within the germ itself, and producing an effect on the constitution of the individual. Certain organs of the embryo might be better supplied with nutriment than others, and, in consequence, become larger or more vitally active in the resulting body. And it may be that this difference in nutrition would have some influence upon heredity; perhaps the weaker, perhaps the stronger, molecular groups being most under control of hereditary influences, and developing accordingly.

If the possibility of such a state of affairs as this be admitted, it may aid to explain the peculiarities of variation. We could understand, for instance, why, in two brothers—even two twin brothers—one is more vigorous in this, one in that, organic function; one has this weakness, one that. Here the heart may be specially strong or weak; here the lungs may be specially active; here the muscular, here the nervous, tissues may be particularly well-developed; here there may be a powerful bodily frame, there a large brain and superior intellect. Similar variations may occur in the digestive and excretory organs, the glandular activity, the deposition of pigment, and other organic conditions. Or one brother may have a general advantage in nutrition over the other, becoming larger and stronger throughout. Differences in the general form of the body, in its fat-making proclivities, in its degree of vital energy, might arise from similar differences in powers of assimilation of the molecular groups of the germinal cell.

The above is offered as a suggestion of a conceivable cause of organic variations. It, unfortunately, belongs to that wide category of hypotheses which are not open to proof. It is not the only suggestion that presents itself. Another influence at work—perhaps a secondary result of that described—is what is known as atavism. As the influence mentioned is a variation in growth force, atavism seems due to a check in development, the organism not attaining its full unfoldment. Atavism is usually considered as applying to the whole organism, but it may confine its action to certain parts of the organism while the others attain full development, thus producing conditions whose atavistic origin is not evident, and which are accepted as results of ordinary variation.

Two conditions are probably concerned in atavism, one being deficiency of nutriment, the other the influence of environment. In truth, there is good reason to believe that two parallel, and, to a certain extent, mutually exclusive, processes are at work in the organism—those of growth and development. The developmental powers only proceed actively under certain conditions. They differ from growth, which is simply increase of tissue, in being changes of tissue, due to chemical or other influence, and set in train by inherent tendencies in the organism.

There are abundant evidences that energetic nutrition acts as a hindrance to development, and yet is preliminarily necessary to it. The two cannot be active at the same time. While nutrition is active, development is latent, and it cannot set in actively without a marked cessation of nutritive energy. Yet it must be preceded by a period of nutritive activity to provide the tissue within which the developmental forces act, and in which a degree of chemical reduction would seem to precede or accompany the re-organization of tissue into new forms. If the preliminary nutrition be wanting, development may be slight and imperfect, or not appear at all, through lack of the quantity of tissue necessary to the changes in organization.

As regards development, or rearrangement of organic tissue, a question arises as to what influences set it in operation, so that, at fixed intervals, nutrition is checked, growth ceases, and active organic change sets in. Inherent tendencies to such change seem to exist in the tissues, their molecular constitution being such that a series of successive rearrangements take place, reproducing conditions which successively appeared in the phylogenetic evolution of the form, and were gone through ontogenetically by the parent. Continuous nutrition, and, apparently, also continuous bodily activity, act to check this process of development, which appears to need cessation of the assimilative process and of physical or nervous activity, all the organic powers being concentrated upon the event about to take place.

Nor is this all that may be necessary. Stimulation from without seems often requisite to start the developmental process. Stimulation from within is perhaps equally necessary, a psychic influence it may be, arising in the inherent instincts of the central ganglion of the nervous system. External stimulation may, in some cases, be necessary to set these instincts in action, while in other cases, they may act involuntarily at a certain stage of ganglionic growth or development. It is apparently due to such influences of instinct, that nutrition is checked and the inherent tendencies to changes in the tissues are permitted to act, the action of instinct being thus perhaps secondary; though it may be that a direct stimulation from the ganglion to the tissues is necessary to set the powers of development in operation. The action of the mental powers may, therefore, be confined to checking nutrition and activity, but may also concentrate the physical energies upon the region of coming change, and set in train the necessary chemical action. All the further powers and tendencies requisite exist in the tissues themselves.

We possess abundant evidence that, in the lower animals, development will not proceed if the surrounding conditions be unfavorable, whatever be the inherent tendencies. The life-history of intestinal parasites furnishes marked examples of this. Such creatures may continue a larval existence for an indefinite period in one host, the development to the mature stage being accomplished only after the second host is entered. Possibly, in the first host, nutrition continues active, and is checked on reaching the second host; but the influence of the new environment may have its special stimulating effect. The development of insects present many cases in point. They often continue long in the larval state, in which nutrition is active, growth rapid, and development checked. Then, during a period of pupal rest and non-nutrition, a rapid development to the mature stage takes place. Adventitious organs, useful to the larva, often develop, and are discarded in the pupal stage, as having no place in the phylogenetic order of development. This is strikingly the case in Echinoderm development, the adventitious organs sometimes forming so large a part of the larval animal that they have the power of swimming and taking food after being discarded, though incapable of digesting it. In this case, the developing portion of the animal is confined to the central life organs. In other instances, the adventitious organs are absorbed and utilized in the process of change.

As an instance of marked retention of the larval conditions, may be mentioned the Aphis, in which no further development takes place through many generations, nutrition being active, and reproduction going on by gemmation. In the autumn, when nutriment begins to fail, the long repressed instincts and developmental powers come into play, and mature insects are produced. The seventeen-year Cicadæ furnish another striking example,they continuing as larvæ during a very long period of underground nutrition, and developing to maturity only when unfolding instinct induces them to seek the surface. Numerous examples of a similar kind may be found in the Hydrozoa, in which development is checked at several larval stages, in each of which a different environment or kind of activity exists.

The ants and bees, among insects, are of high interest in this inquiry. The bees, for example, seem to have worked out the whole problem for themselves, and can produce workers, queens and drones at will. It seems a simple question of nutrition whether queens or workers shall appear, the worker larvæ being underfed, the queen richly fed and with fuller space for growth. They all pass through stages of pupal development, in a state of rest and non-nutrition, but the fully-fed larva becomes a mature female, the illy-fed ones become immature females. During the subsequent life of the latter, no opportunity for complete development occurs, activity and nutrition being incessant. In the ants, somewhat similar conditions exist.

Certain of the Amphibia present marked instances of the influence of environment as a stimulus to development. A tadpole kept forcibly in the water does not become a frog. The Axolotl, a gilled salamander, seems to have a power of choice in this particular. It continues a water breather while it elects to remain in the water, but loses its gills and develops into the lung-breathing Amblystoma if it leaves the water for a land life. Another interesting instance of this appears in the Leptocephali, peculiar larval fishes, small, pellucid and cartilaginous, which are found floating far out in the ocean. Gunther considers them the offspring of various marine fishes which have been swept away from their normal environment and their development in consequence arrested. This is, perhaps, due to deprivation of the requisite nutriment.

Many examples of a check to the full development of the higher animals, through insufficient nutrition, might be given, were it advisable to extend this examination. In the lower animals, so far considered, there would seem to be a competition between two instincts, one the instinct to devour food and move actively, the other the instinct to cease eating and enter a state of rest. External conditions are, perhaps, only influential in giving the precedence to one or the other of these instincts, though, in most animals, the latter instinct in time seems to gain a controlling influence, and development in consequence proceeds.

The instances here given are extreme ones, and are of much value from their bearing upon the question at issue. Doubtless there are many minor steps of development which need no special preparation, and which take place during the ordinary activities of life. Such steps might be pointed out in the invertebrates, while vertebrate development is generally of this character, its stages appearing successively without need of marked cessation from food or activity. Yet the examples adduced are probably exaggerated instances of what always takes place, a period of nutrition of the organ involved, a temporary check to nutrition, a diversion of energy to that organ, and a more or less rapid developmental change. If this change is a considerable one, as in the casting of their shells by crustaceans, a physical weakening results, and new tissue must be built up before the new shell can appear. A similar weakening is apt to appear in man during the development of puberty, and various other instances might be given.

All this leads back to the question of atavism. The changes indicated may not be solely due to nutrition and stimulation, but may be controlled in a measure by the original germinal conditions, the degree of developmental vigor which exists in each of the molecular groups of the germ cell. If any of these is weakly constituted, or imperfectly organized, its general development may cease before the ultimate phase is reached, or it may be imperfect, and the resulting animal lack some part, as in the absence of a hand or arm. This may be the ordinary cause of the phenomena of atavism, the original weakness of the germ causing a cessation of development before the final stage is reached. This check seems often to occur at the level of some immediate ancestor, but occasionally acts at a considerably more remote stage. Again, weakness in a special region of the germ may check development of some organ at an ancestral stage, while the remainder gains full development. Such a result, while due to atavism, would yield no evidence of it. To this class of influences may be due many of the variations in offspring which so commonly occur.

There is a further possibility to be considered: that of a condition the reverse of atavism. While defects occasionally appear in the mature body, an excess of development also at times appears in certain regions. This may be a duplication, as in the fingers and toes, the development of some limb or organ to a larger size than in the parents, or the appearance of an excrescence which has no paternal counterpart, yet, perhaps, may prove of advantage to the individual. If defects are due, as here suggested, to deficiency of energy of development, or partial formation in some molecular group of the germ, excess may, perhaps, be due to the opposite influence, a superabundance of energy, or excess of molecules in the group. The molecular groups from which the organs, tissues or members of the body are supposed to be derived, may possibly vary, as above-said, both in energy and in formative conditions, and minute variations in the germ may yield marked variations in the adult.

All this is offered as conjectural. If it be based on fact, some important conclusions follow. To atavism, partial or complete whether due to original germinal weakness or subsequent lack of nutrition, degeneration may be due. The imperfect or poorly developed offspring, if it should prove fitted to some other mode of life than that of its race, might survive and yield descendants like itself. Through such a process, long continued, the extreme degeneration occasionally seen might appear.

On the other hand, if the molecular groups can possess excess of energy or superfluous material, the result may be seen in some unusually large organ or greatly developed tissue, or a general superiority of the whole body; or, again, in the appearance of some duplicate part or excrescence. Such an excess, if advantageous, might, as in the opposite case of degeneration, induce new habits in the animal, and, in time, lead to marked differences in species. If the excess appeared in the nervous system generally, or the brain particularly, an important psychical advance might result. It is certainly not impossible that the extraordinary intellectual powers which occasionally appear in the offspring of parents of ordinary mental development may be due to this cause, and that the gradual advance in mental ability in the animal kingdom, with the superior powers of attack and defence thence arising, have a similar origin.

The problems here dealt with are very obscure ones. In considering them we are, perforce, confined to hypothesis, since facts are beyond our reach, other than such phenomena of organic nature as have been adduced. Certainly the causes of individual variation lie low down in the process of development, and while, perhaps, due in a measure to environmental forces at work on the embryo or larva, are probably due in a much larger measure to conditions connected with the organization and early development of the germinal cell.